Motion

A Descriptive *Model* for Particles

AP Physics 2023-24 with Mr. Porter

Lab Results:

- The buggies moved with a ***constant velocity***
  - means that it changed its *position* equal amounts for each equal change in *time*
- ***Velocity*** ($\bar{v}$) is represented by the *slope* of the position vs. time graph
  - how "fast"
  - AND what direction
- ***Speed*** is the steepness of the slope:
  - it tells us the rate that position changes with time
  - steeper slope == faster
- The **initial position** (x_0 or y_0) of the object is the vertical intercept
  - it tells us where the object is at clock reading 0.

Mathematical Models

General Mathematical Mode:

$$x = \bar{v}t + x_0$$

Specific Mathematical Model (example):

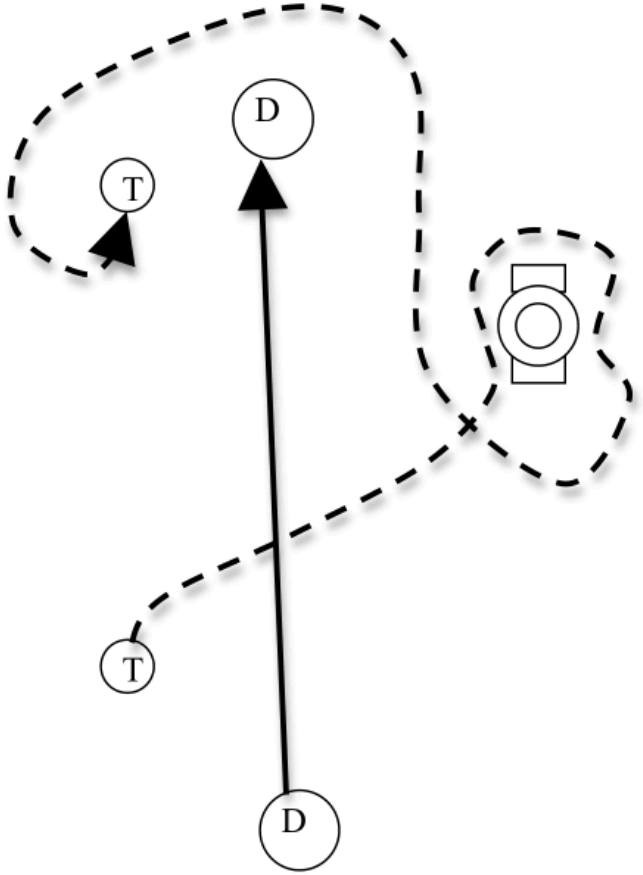
$$x = (25\ \text{cm/s})t + 250\ \text{cm}$$

Narrative Model:

"The toy car started at a position of 250 cm and moved in the positive direction at a speed of 25 cm/s."

Defining "How Far"

Who went further? Dorothy or Toto?



Displacement

- Change in position of an object
- $\Delta x = x_f - x_0$
- Includes direction

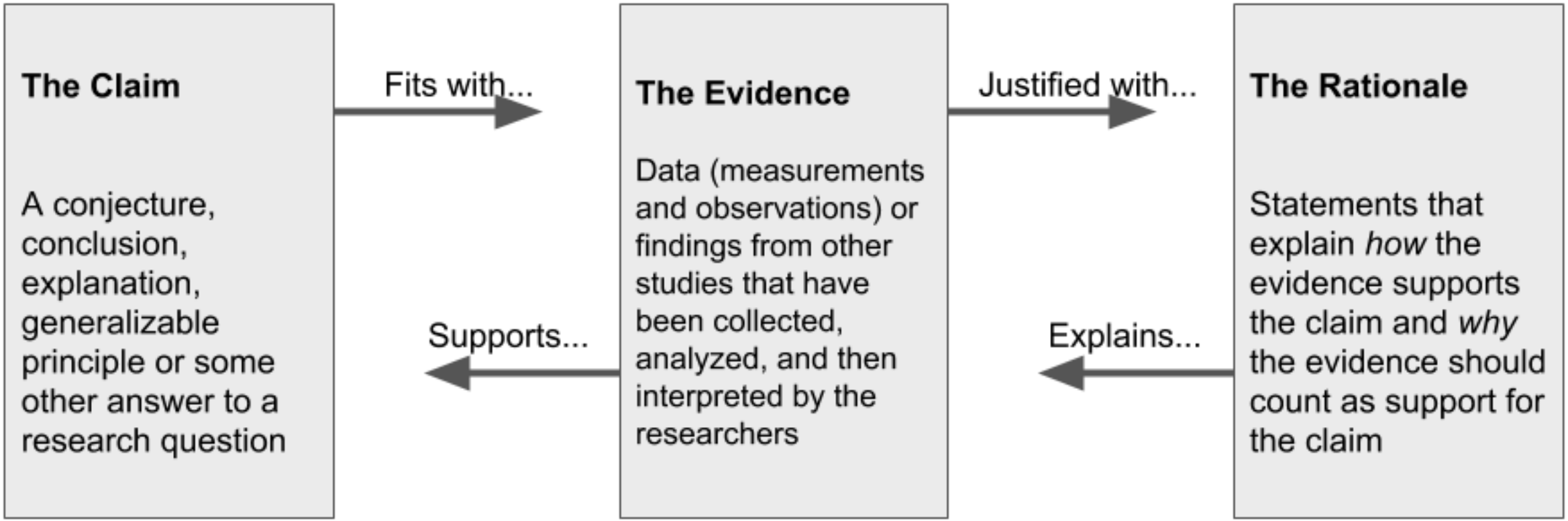
Distance

- the **magnitude** (or size) of displacement between two positions
- more often referred to as **distance traveled** which is the total length of the path traveled between two positions

Position

- Where an object is at any particular time
- "Location"

The Scientific Argument



CER in AP Physics:

- ***Claim***:
  - Sentence that answers the question.
- ***Evidence***:
  - Explanation of how the evidence supports the claim.
    - Should include details!
    - Refer back to the question, include any data, diagrams, or graphs.
- ***Reasoning***:
  - Physics principle, such as an equation, law, or definition.
    - This is general, do no include specific details.

Game: Soup, Salad, or Sandwich

1. Write a Claim-Evidence-Reasoning statement arguing whether the shown food is a soup, salad, or a sandwich.


Soup, Salad, or Sandwich?


Soup, Salad, or Sandwich?

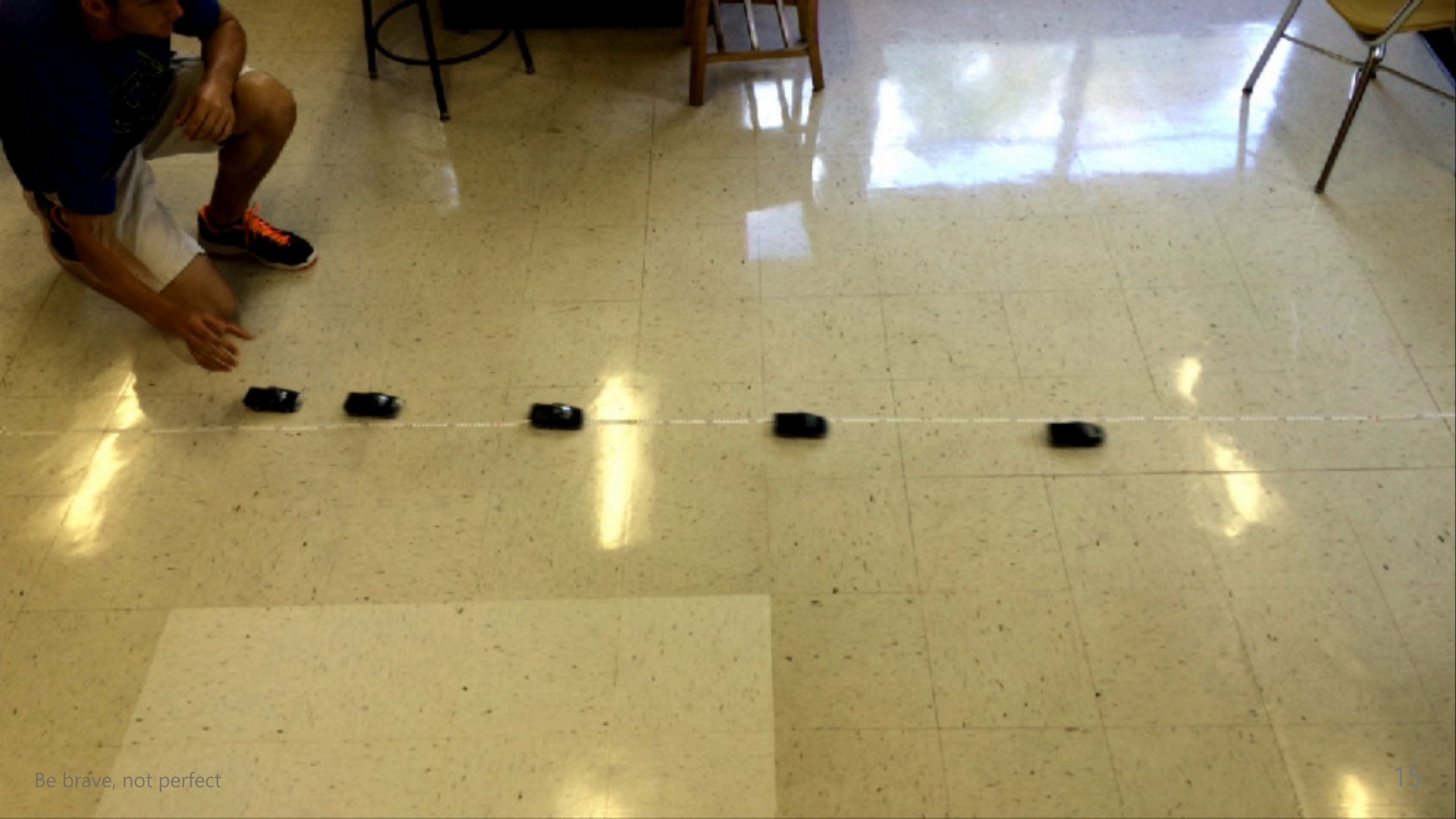
class: invert

Soup, Salad, or Sandwich?

Soup, Salad, or Sandwich?

CER

Does the object in the image move with a *constant velocity*?




Be brave, not perfect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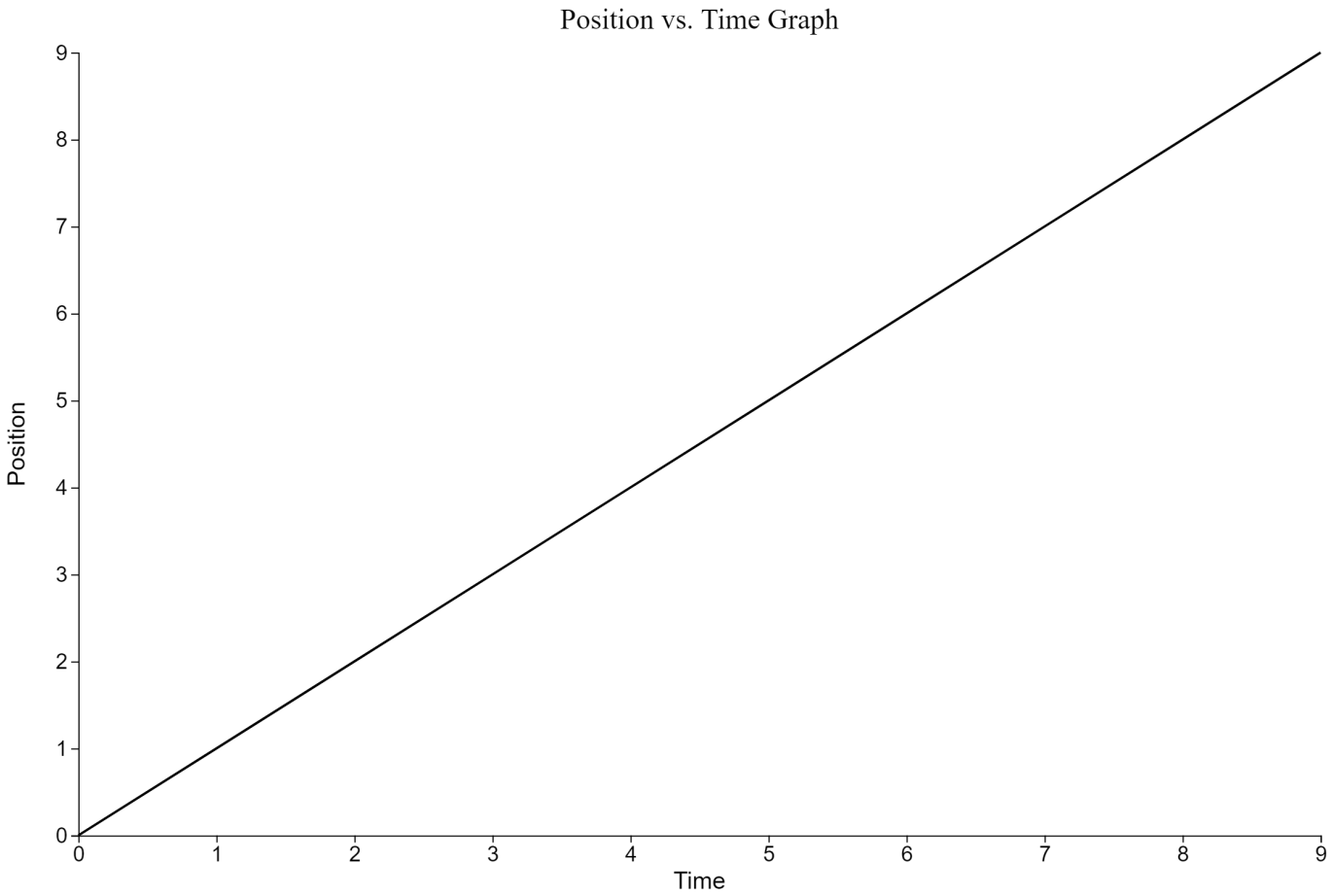
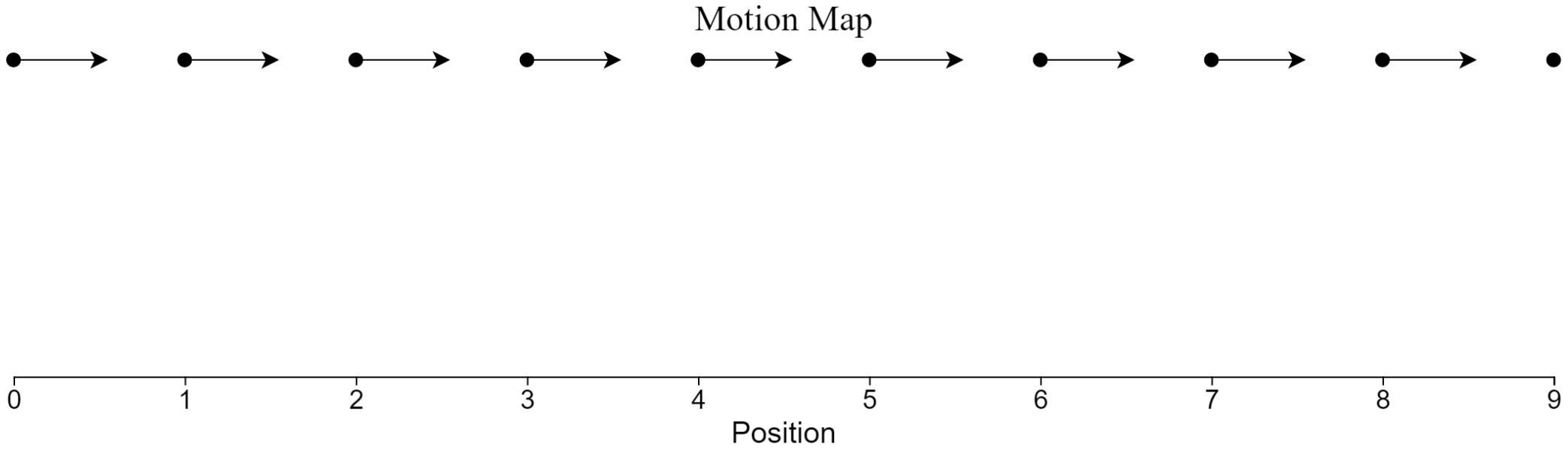
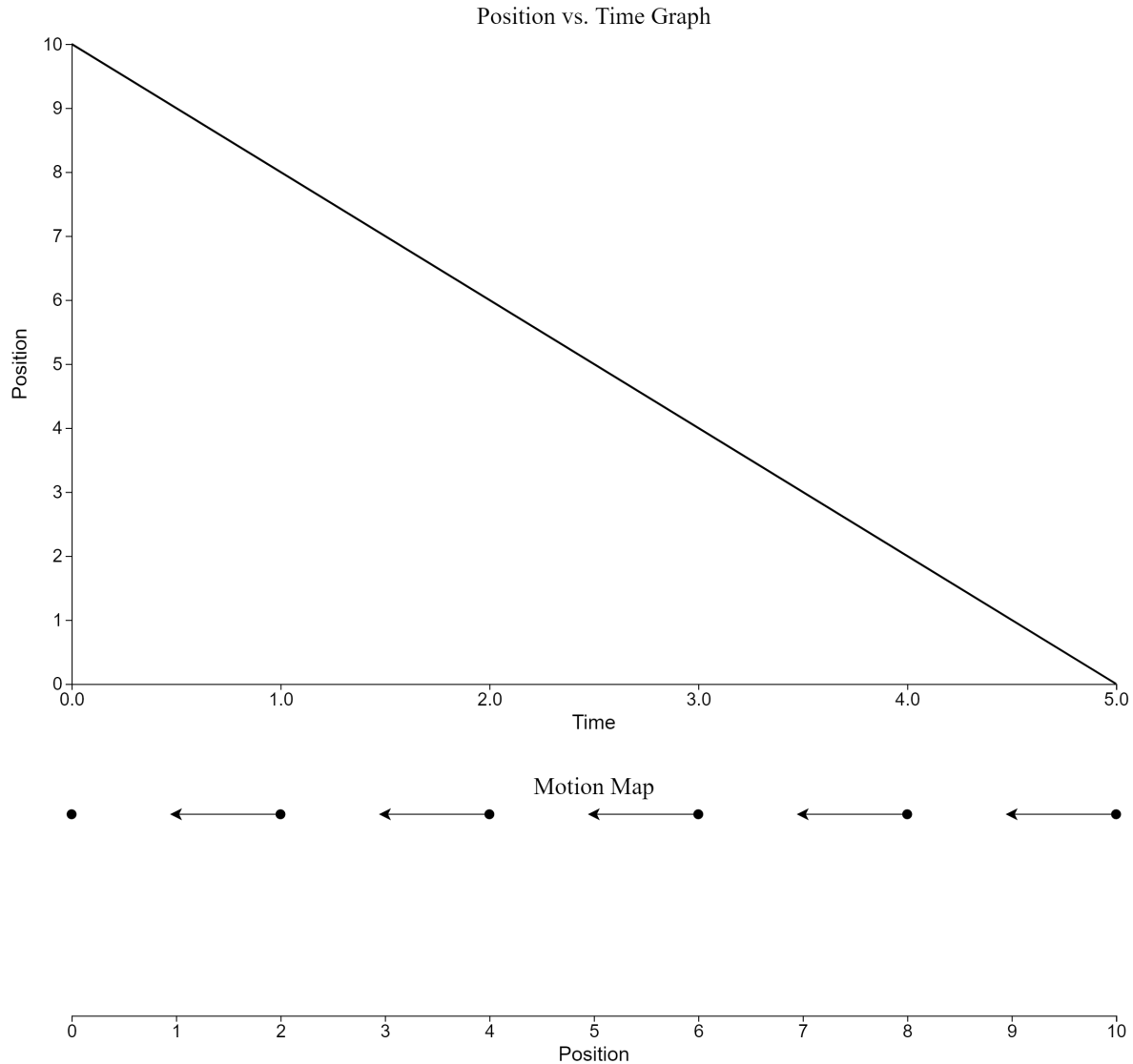
OSAKA
#XFIGHTERS

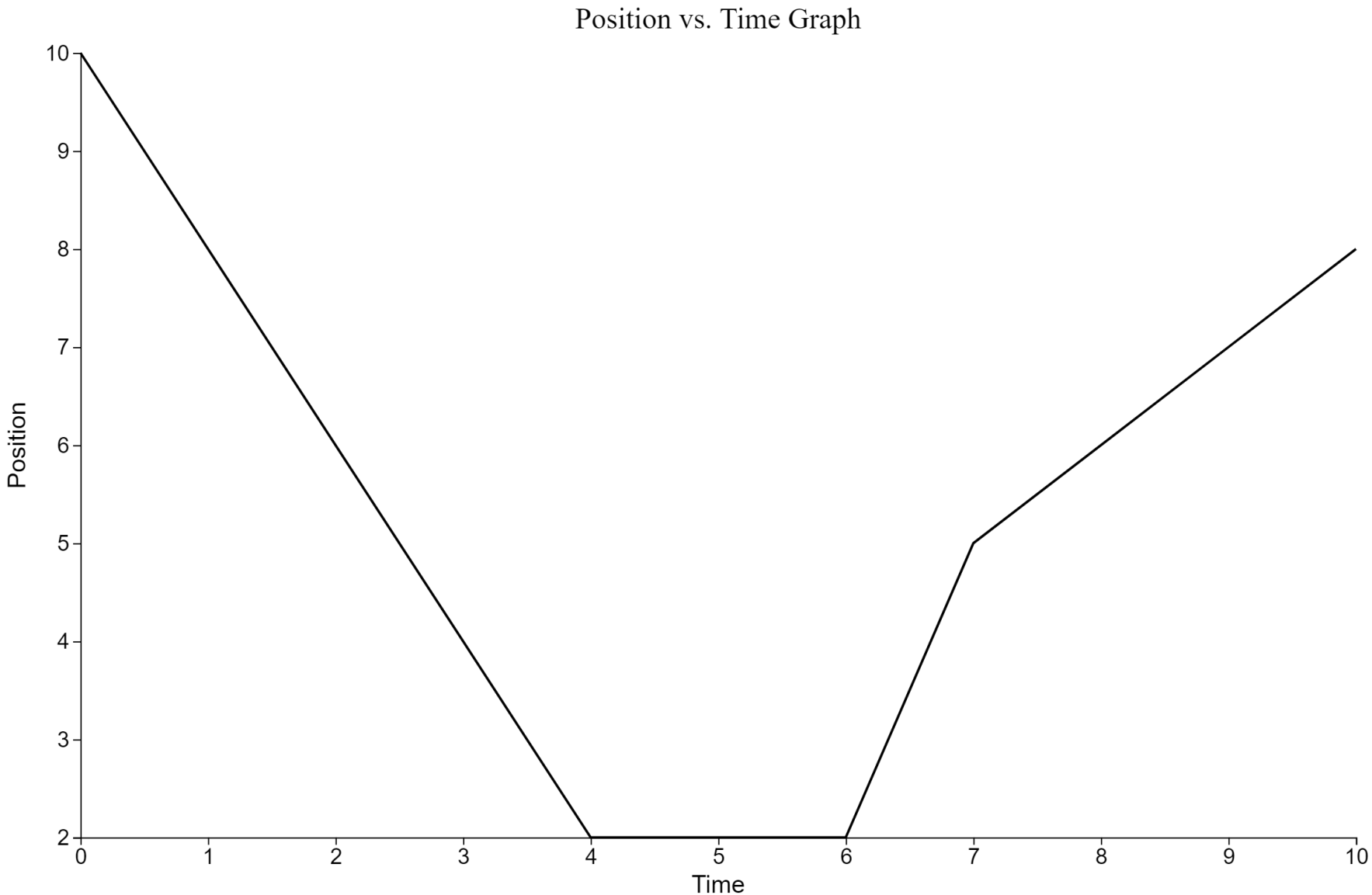
Motion Maps - Represent this pictorially:

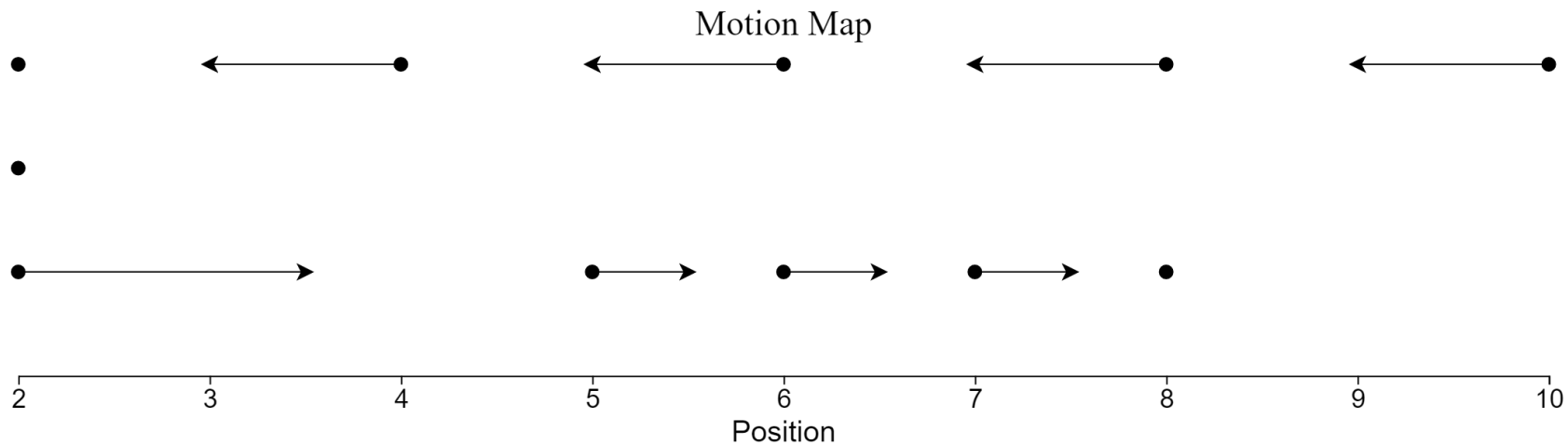


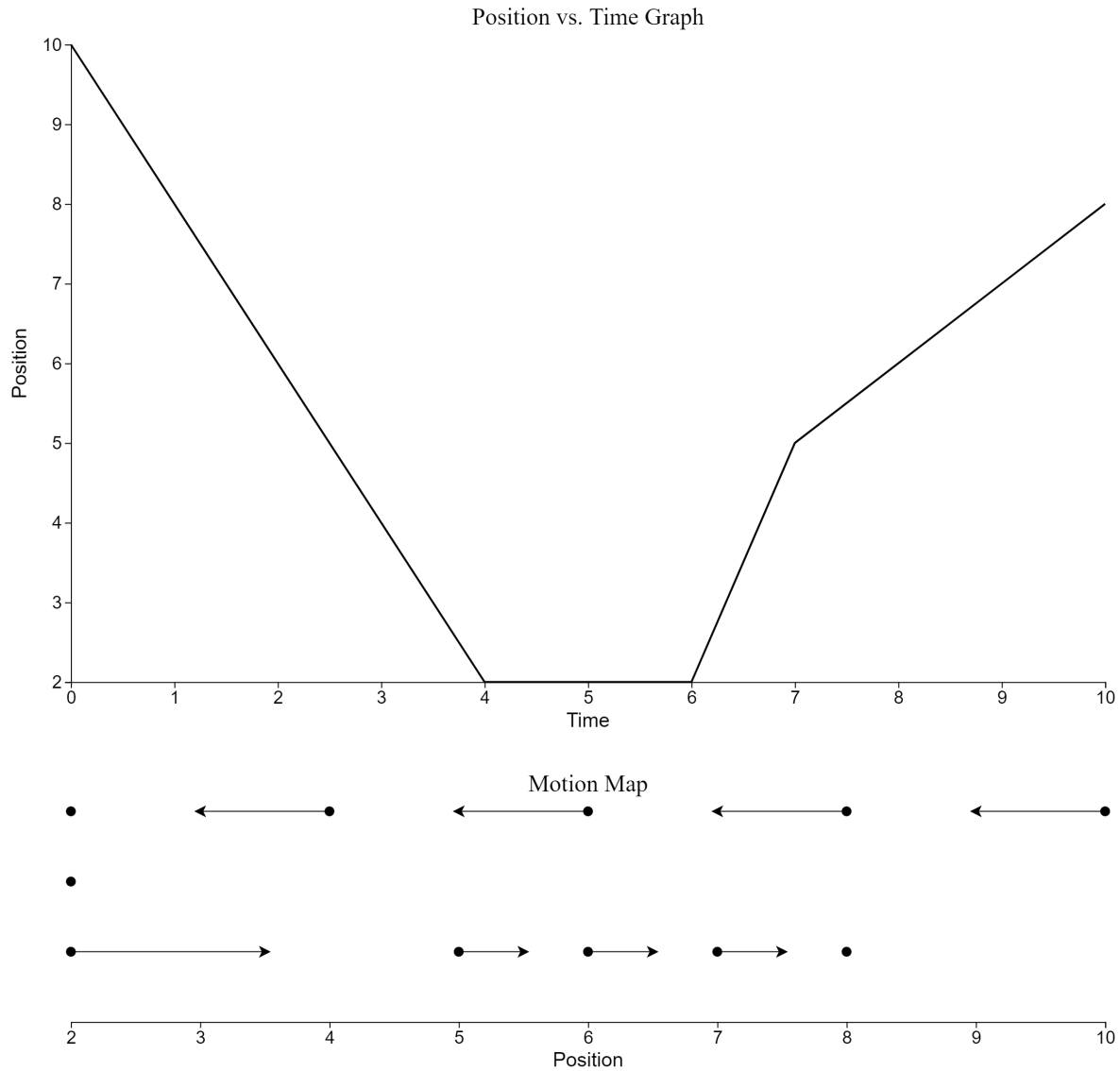
Motion Maps



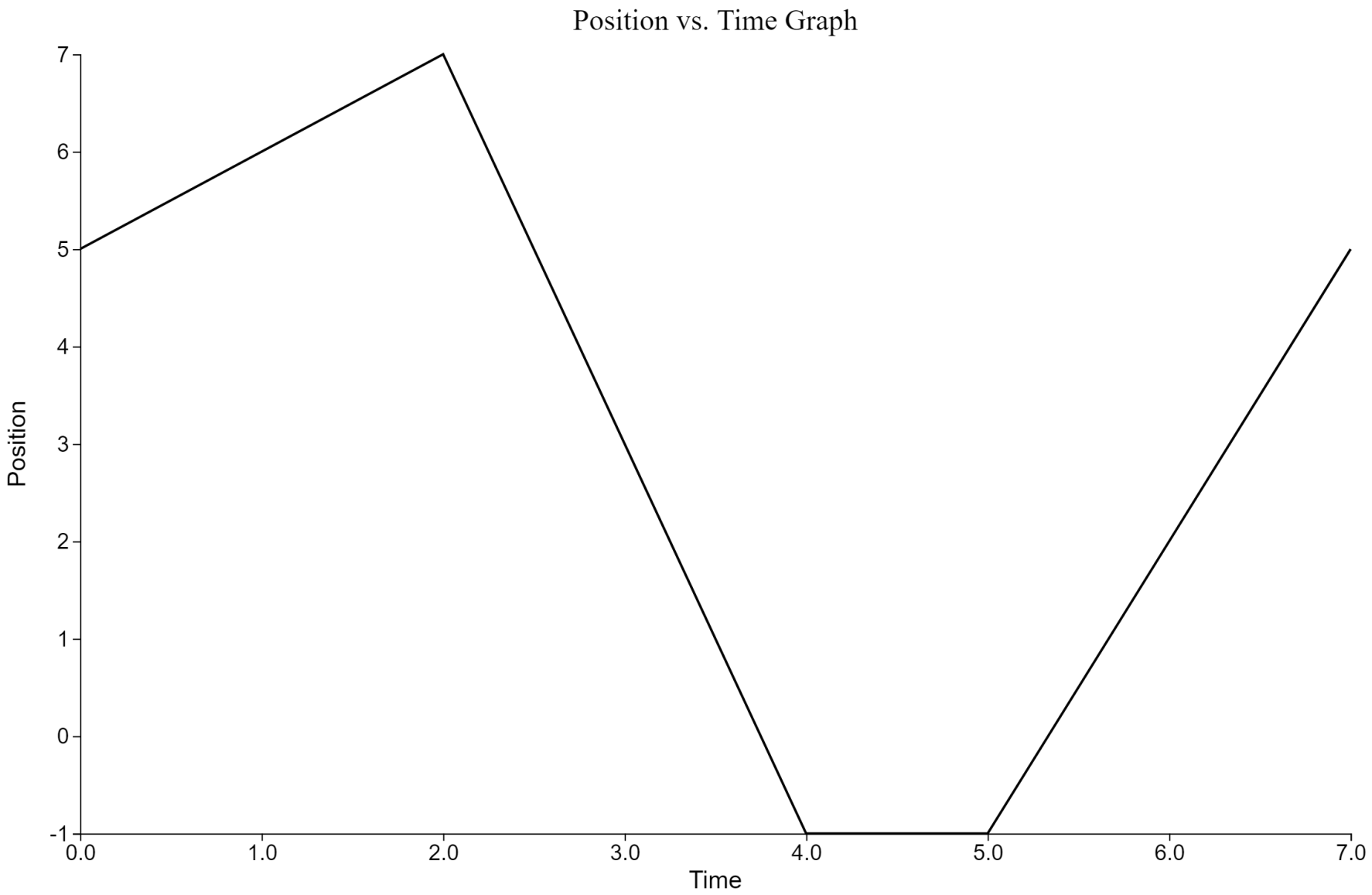

Position vs. Time Graph
Position
Time
0
1
2
3
4
5
6
7
8
9
10
0.0
1.0
2.0
3.0
4.0
5.0
Motion Map
Position
0
1
2
3
4
5
6
7
8
9
10

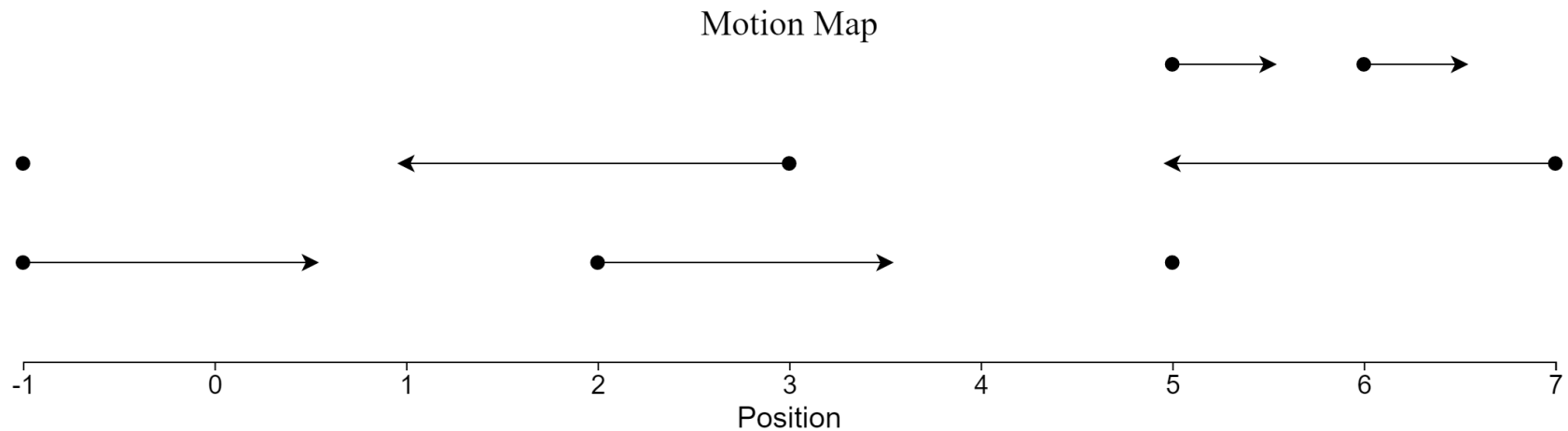

Position vs. Time Graph
Position
Time
10
9
8
7
6
5
4
3
2
0
1
2
3
4
5
6
7
8
9
10


Motion Map
2
3
4
5
6
7
8
9
10
Position


Position vs. Time Graph
Position
Time
Motion Map
Position

Try it…

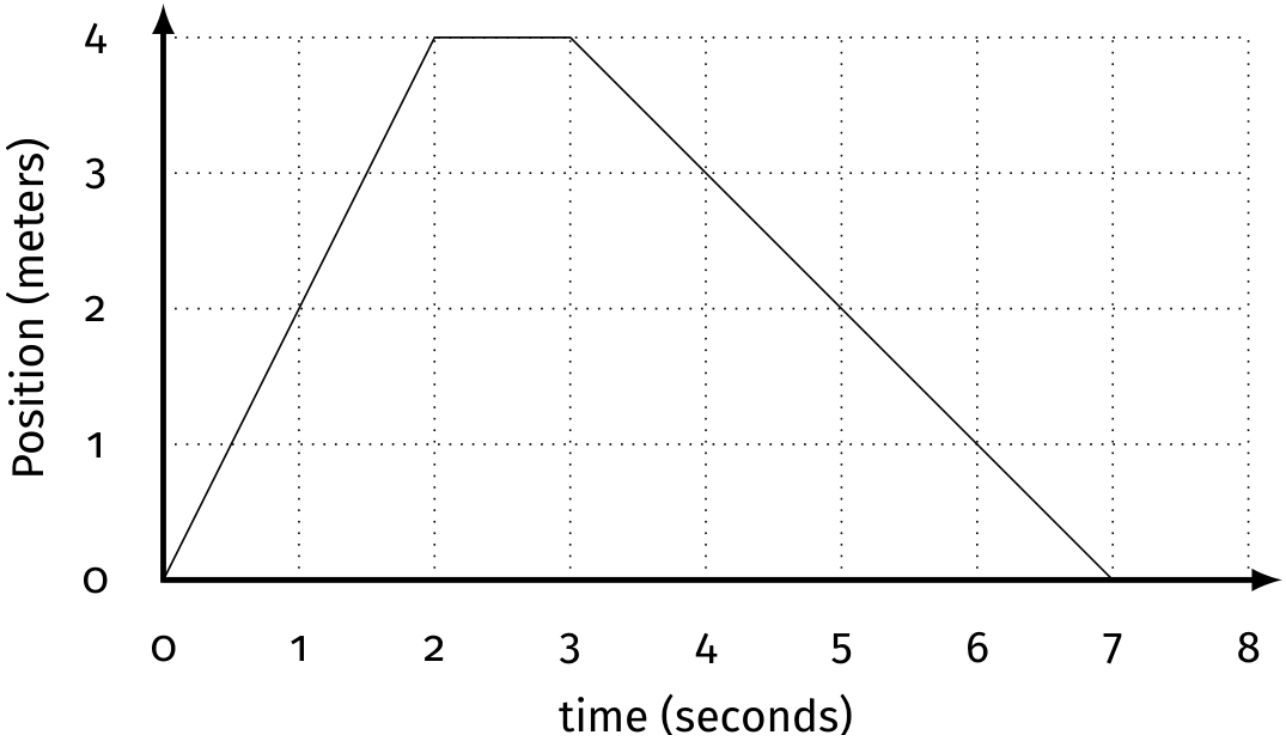

Position vs. Time Graph
Position
Time
7
6
5
4
3
2
1
0
-1
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0


Motion Map
-1
0
1
2
3
4
5
6
7
Position

Practice: Complete individually and compare

Given the following position vs. time graph

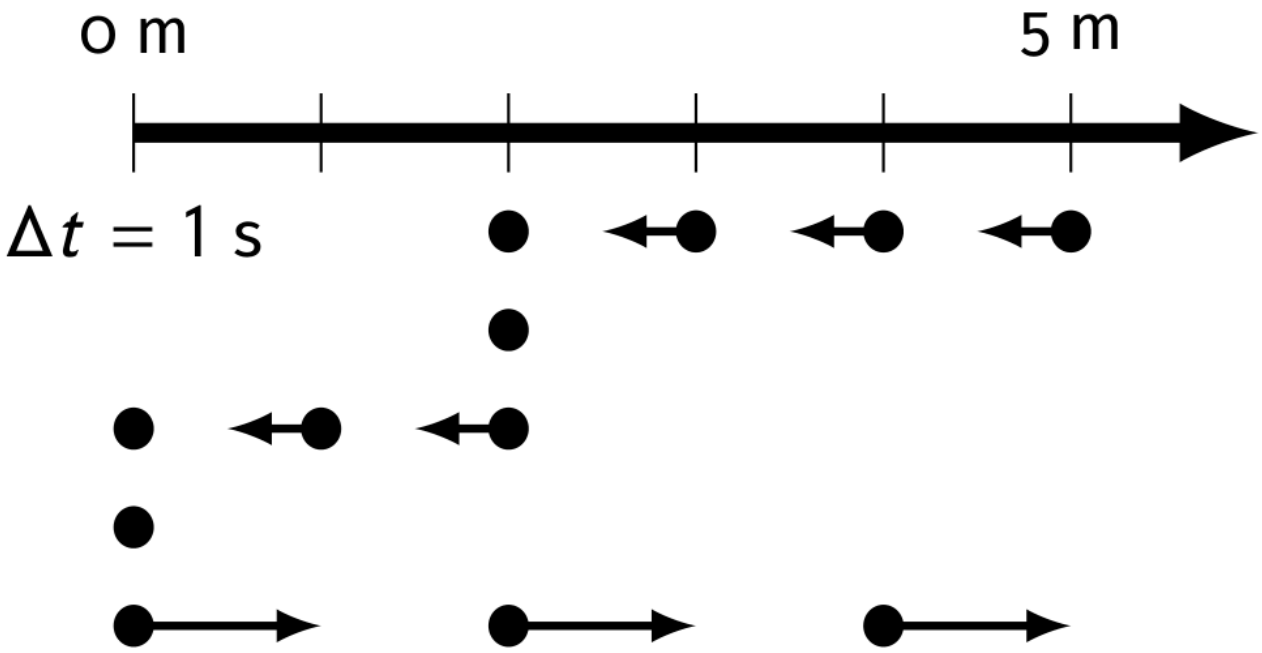
1. Draw a motion map with one dot for each second
2. Describe the motion in worsds

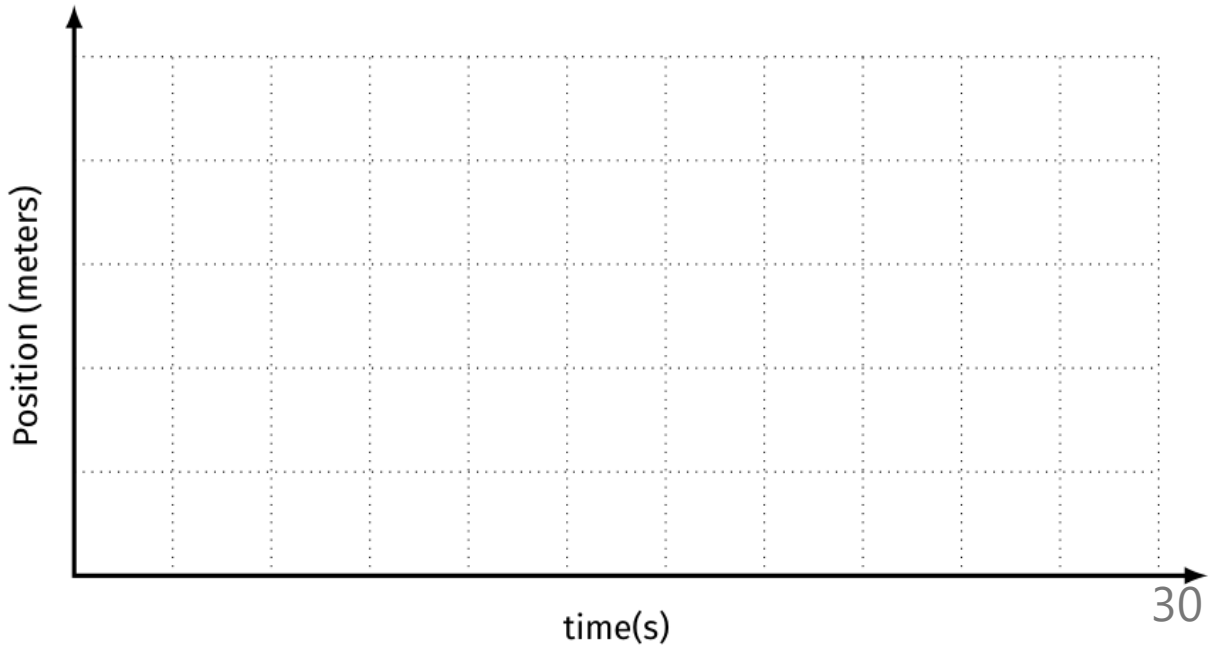


More Practice

Given the following motion map, where positions have been recorded with one dot each second,

1. Draw a position vs. time graph
2. Describe the motion of the object in words



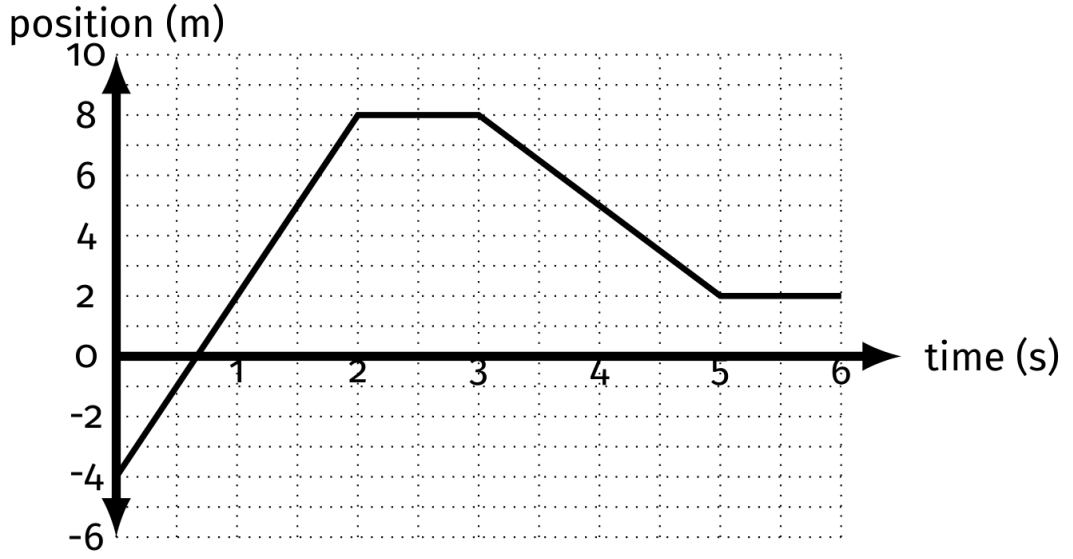


Motion Sensor Lab

Analyzing Position-Time (XT) Graphs

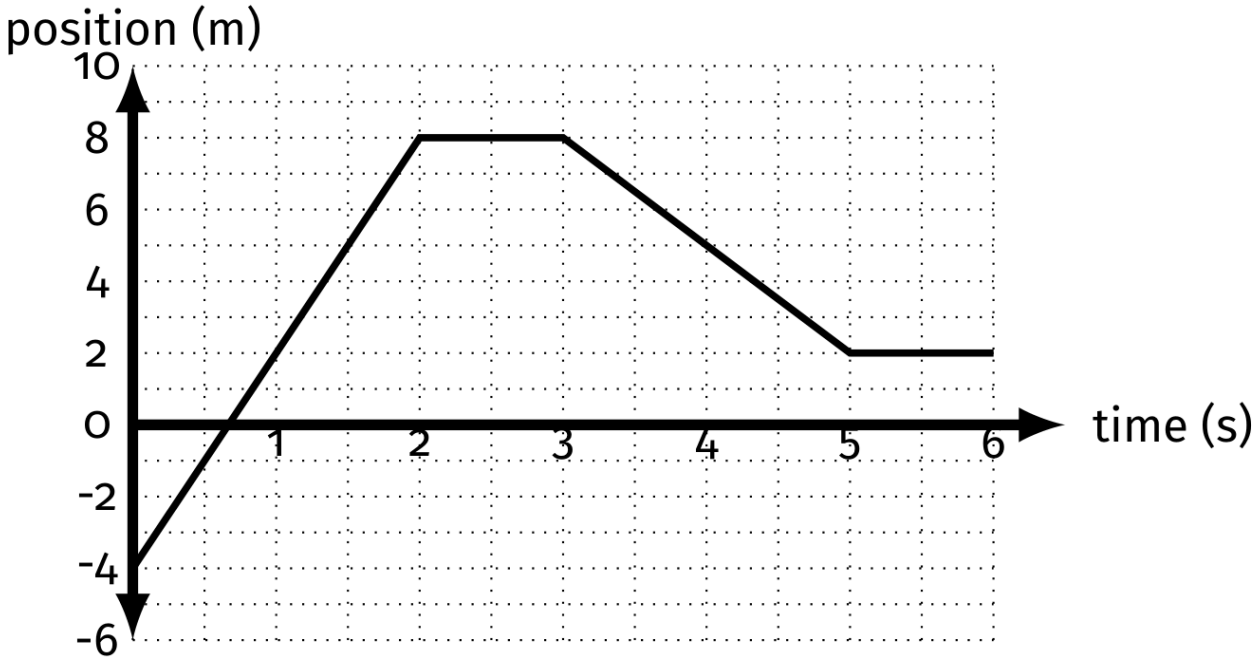
For the following position vs. time graph, consider the positive direction to be north.

1. When is the object moving North? South?
2. When is the object stopped?
3. When is the object North of the origin?
4. What is the velocity of the object at $t = 1$ s? $t = 2.5$ s? $t = 4$ s? When it is at the origin?



Analyzing Position-Time (XT) Graphs

5. When does the object change directions?
6. What is the total *distance* the object travels?
7. What is the total *displacement* of the object?
8. What is the *average velocity* of the object?
9. What is the *average speed* of the object?



Average Velocity

Dispalcement divided by the change in time.

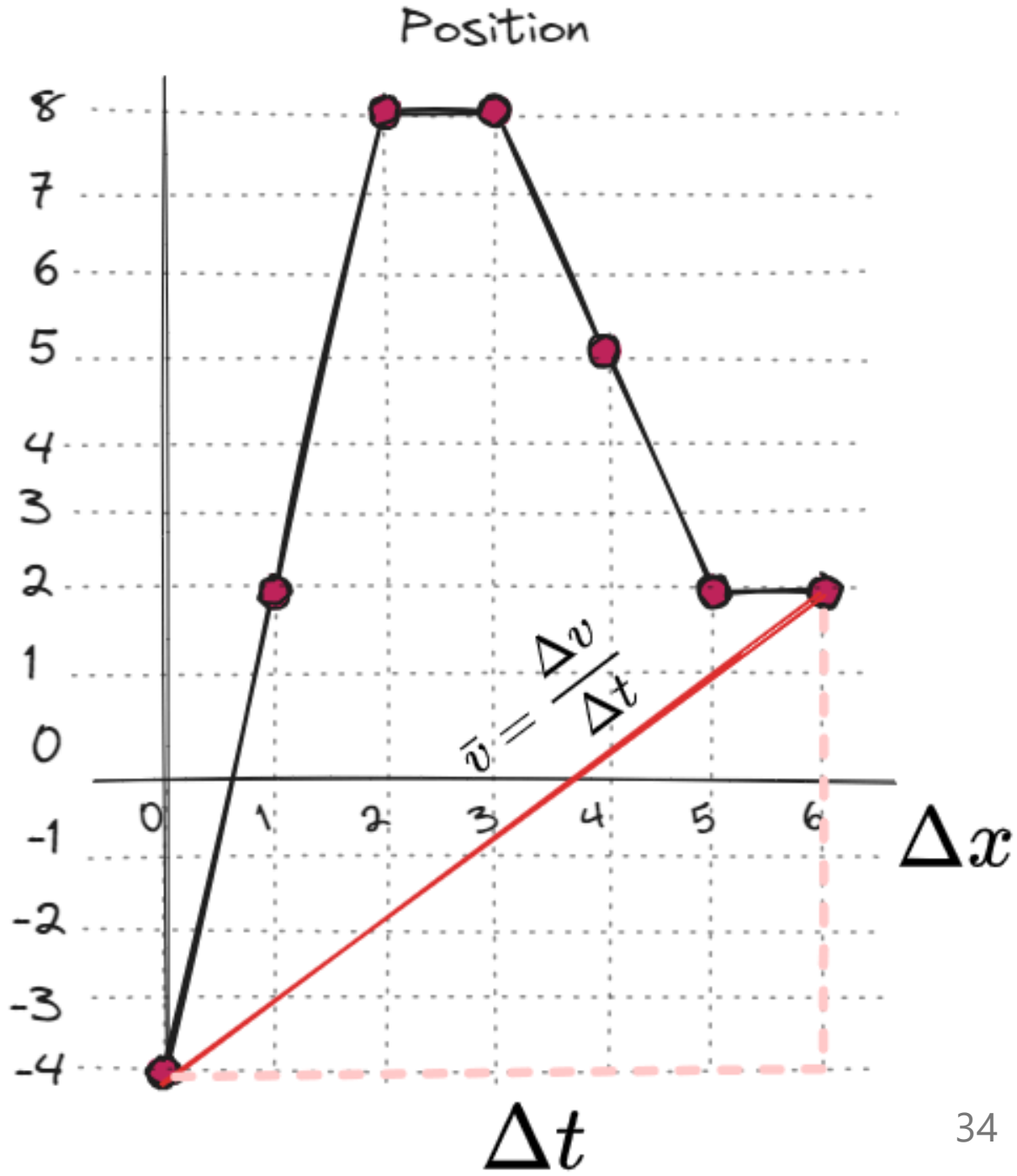
$$\bar{v} = \frac{\Delta x}{\Delta t}$$

"The average slope of the graph"

Average Speed

Total distance divided by change in time

$$|v| = \frac{dist}{\Delta t}$$



Instantaneous Values:

- "*at that moment*"
- Value at a specific time

Instantaneous Velocity

- Velocity at a specific time
- The slope of the position vs. time graph ***at that time measurement***

Instantaneous Speed

- Magnitude of the velocity

Mathematical Modeling & Making Predictions

Constant Velocity Particle Model

$$x = \bar{v}t + x_0$$

- x ➡️ final position
- $\bar{v}$ ➡️ constant velocity
- t ➡️ time
- x_0 ➡️ initial position

A racecar reaches a speed of 95 m/s after it is 450 meters past the starting line. If the car travels at a constant speed of 95 m/s for the next 12.5 seconds, how far will the care be from the starting line?

1. Sketch and label the situation
2. Physics diagrams: position vs. time graph, motion map (qualitative)
3. Mathematically model
4. Solve

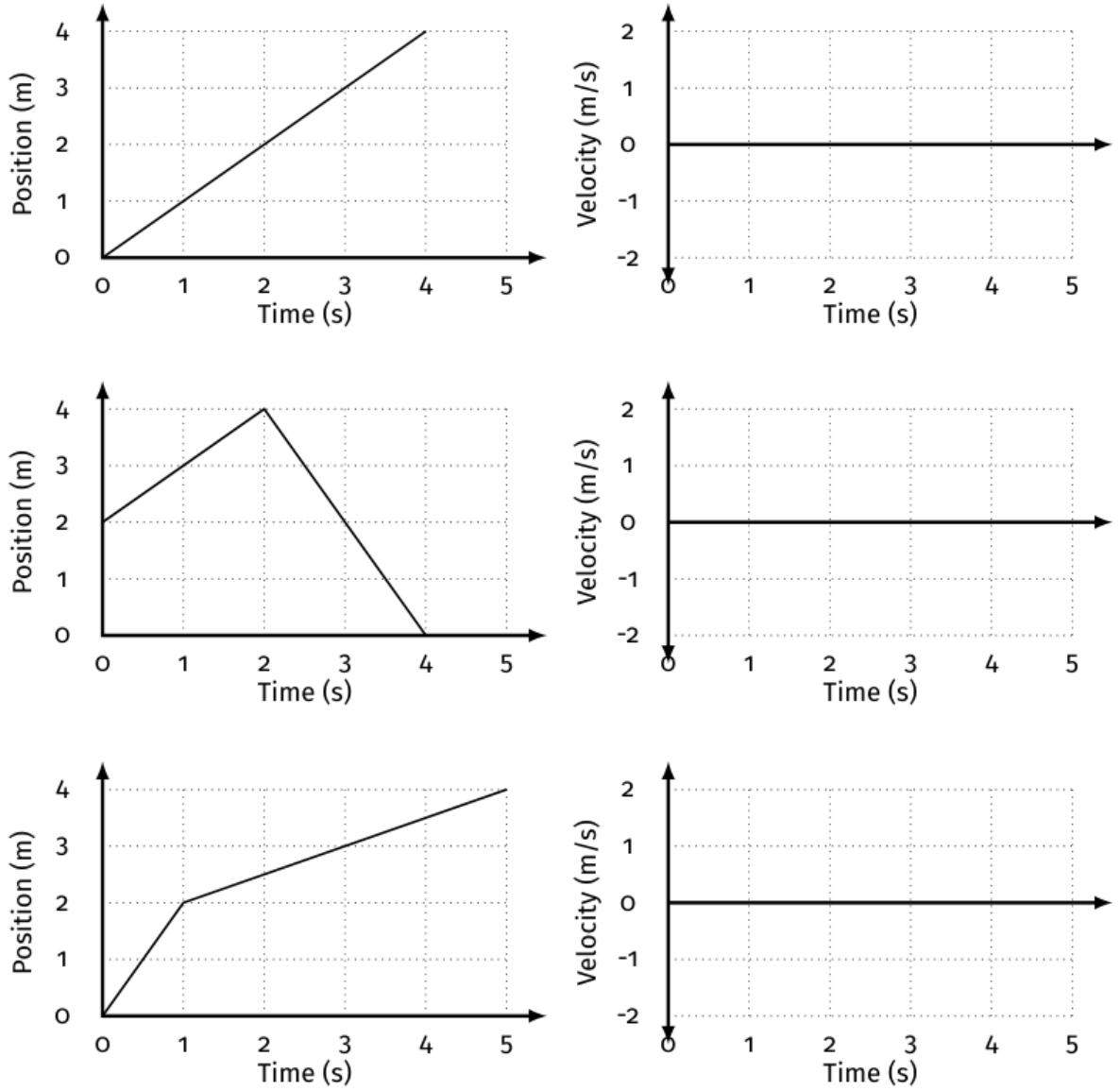
Mr. H waits patiently as two beetles race across the 35.8-cm length of the cereal box. According to Mr. H's estimates, Beetle A averages 0.230 cm/s and Beetle B averages 0.454 cm/s. Beetle A has a 4.1-cm 'head start' (when Beetle B is at the far edge of the box). What is the separation distance (in cm) between beetles when the first beetle reaches the end of the box?

1. Sketch and label the situation
2. Physics diagrams: position vs. time graph, motion map (qualitative)
3. Mathematically model
4. Solve

Velocity vs. Time Graphs

VT Graphs

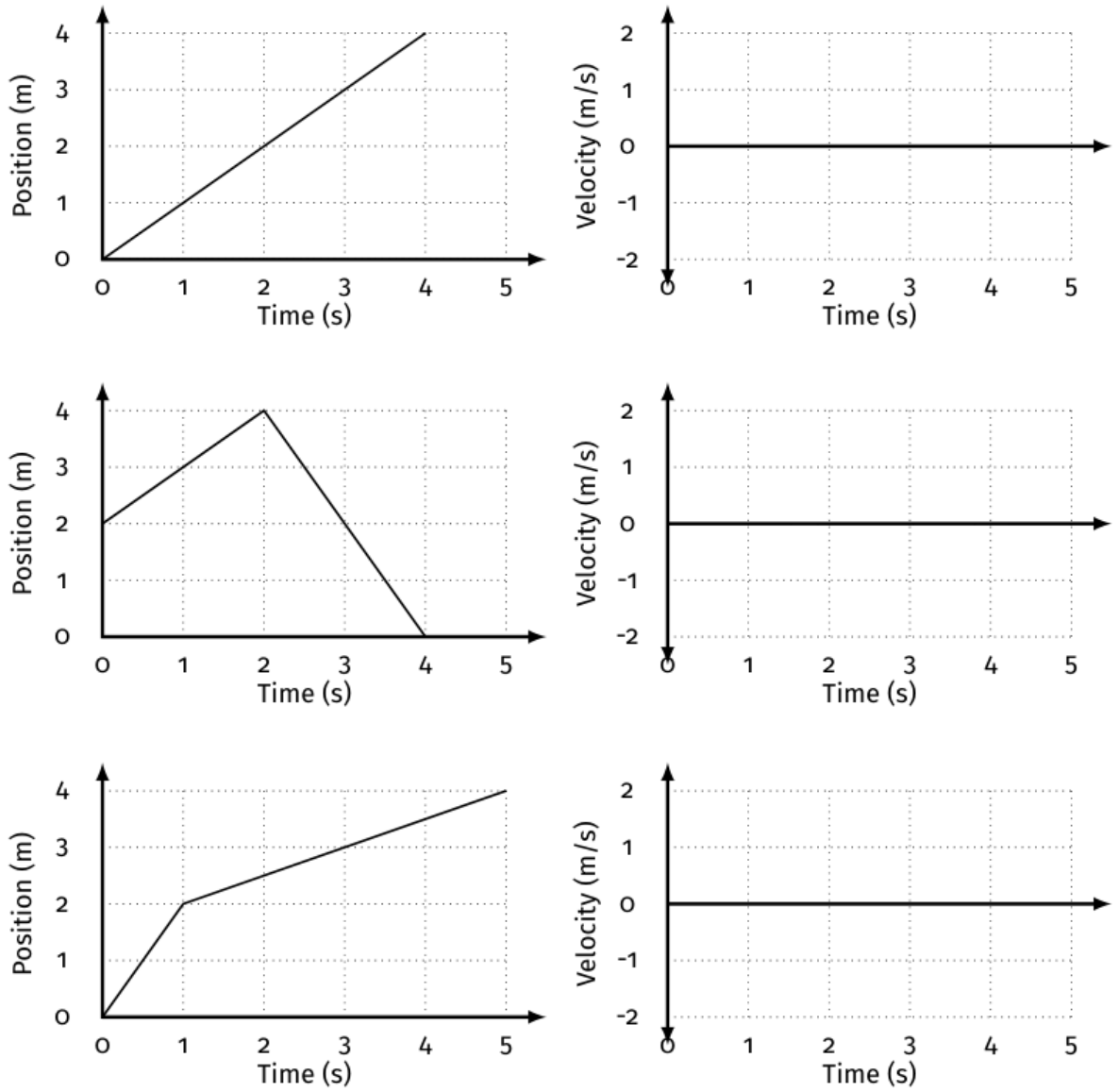
1. Draw the velocity vs. time graph for an object whose motion produced the position vs. time graphs shown below.
2. For many graphs, both the ***slope*** and ***area*** between the line and the horizontal axis have physical meanings. What does the ***slope*** of the position vs. time graph tell you about the motion of an object?



VT Graphs

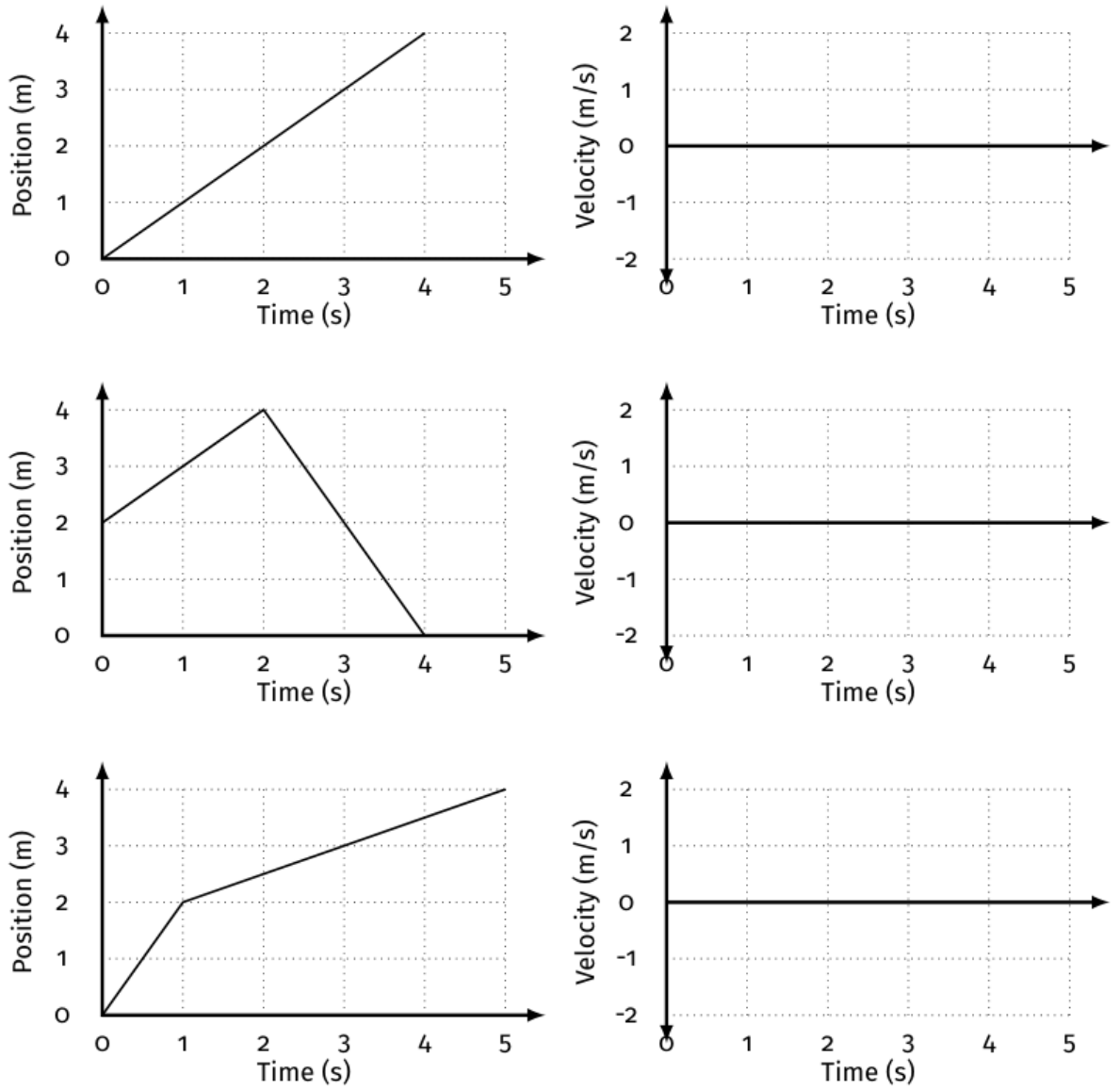
3. Complete the following chart and show your work

	Δx from XT Graph	Area "under the curve" of VT Graph
1		
2		
3		



VT Graphs

4. Looking at the velocity vs. time graphs, determine the units for a square of area on the graph.
5. What does the "*area under the velocity-time graph*" tell you about the motion of the object?

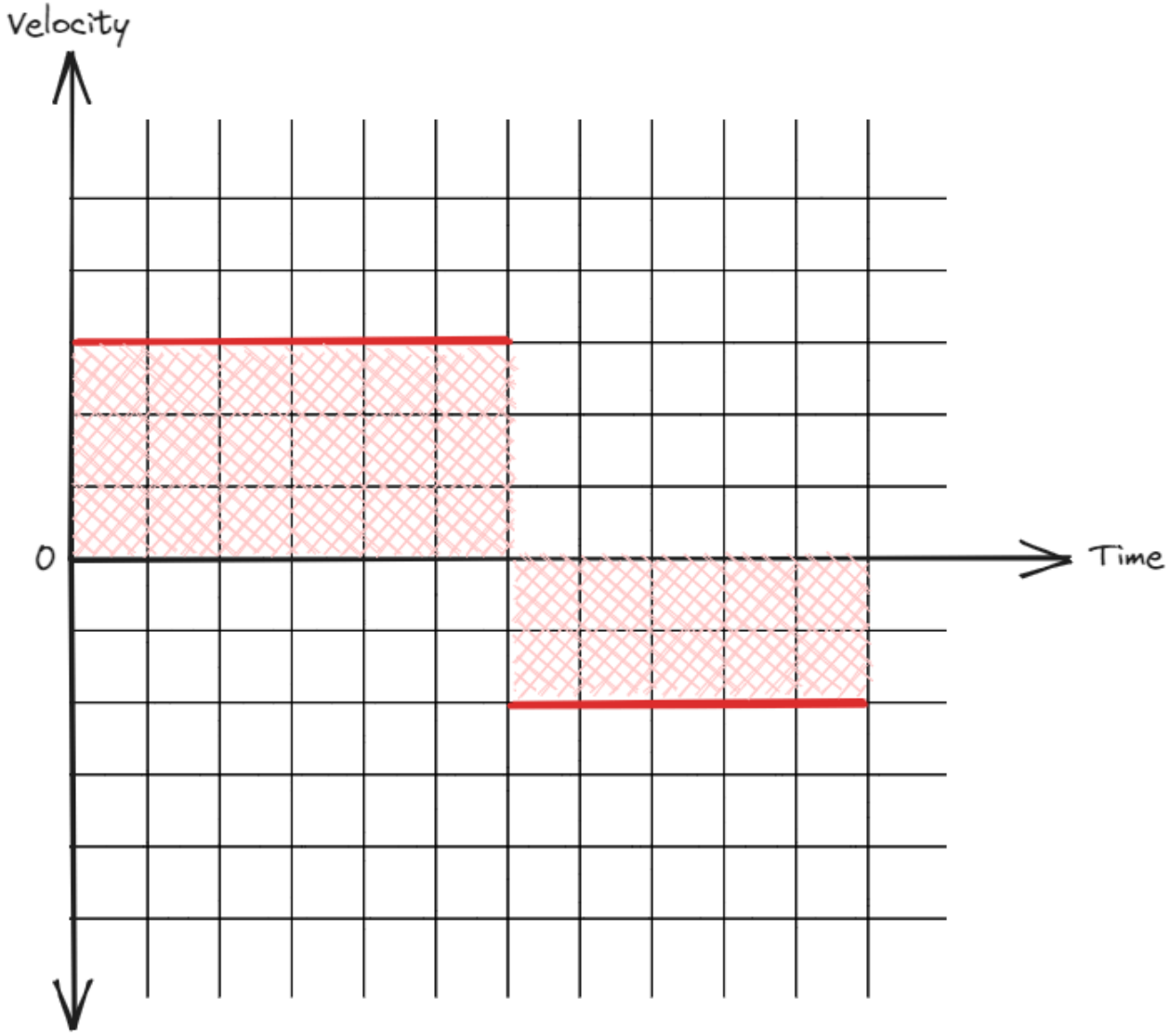


Area of VT Graph

- Area "under the curve" represents the displacement (*change in position*) of the object.
- Areas can be negative because that represents the direction

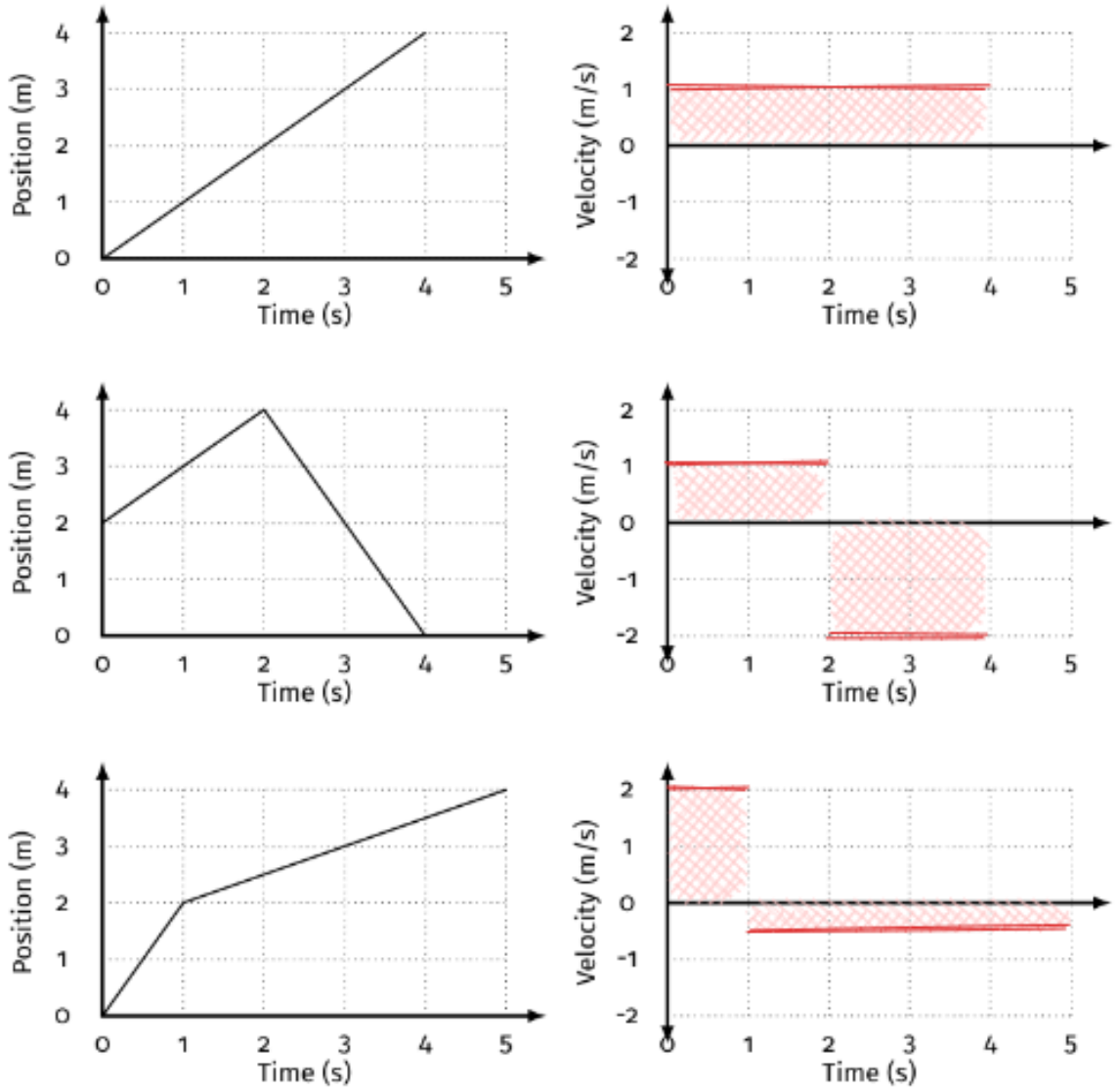
$$\Delta x = \bar{v}t$$

- Add multiple segments together, including the sign to get the total displacement of a piecewise motion



Area of VT Graph

1. Area = Δx = 4 m
2. Area = Δx = -2 m
3. Area = Δx = 4 m



Up Next...

Changing Velocities...